Sisal Fibre: Market Opportunities in the Pulp & Paper Industry

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Presented at Alternative Applications for Sisal and Henequen, a joint FAO/CFC seminar, Rome, Italy, 13 December 2000 (published in FAO/CFC Technical Paper No. 14, 2001, pp 61-74)

ABSTRACT

Fibre extracted from the leaves of the *Agave sisalana* plant and its hybrids can be used to produce high quality papermaking pulp. Sisal pulp has certain characteristics such as high tear resistance, high alpha cellulose content, high porosity, high bulk, high absorbency and high folding endurance which make sisal pulp suitable for many specialty papers. Also, because sisal pulp has physical properties superior to softwood kraft pulp, there may be opportunities to cost effectively replace softwood kraft with sisal pulp in commodity papers. For example, sisal pulp may be used as a reinforcing fibre in high recycle content papers, or its use may permit basis weight reductions while maintaining product quality. Markets for sisal pulp are established in the specialty paper sector; however, currently there are no markets established in the commodity paper sector. This paper explores the following topics that hopefully will provide some background and a direction towards establishing sisal pulp in the commodity paper sector:

- global papermaking fibre consumption
- global nonwood fibre resources
- specialty pulps for specialty papermaking
- HurterConsult sisal pulp market surveys
- potential sisal pulp applications
- hurdles to overcome
- the next steps

INTRODUCTION

Before considering potential market opportunities for sisal fibre in the pulp and paper industry, we must first consider the fibres currently in use and certain trends that may favour using sisal fibre in the future.

This paper presents an overview of various topics that I hope will provide a direction for establishing sisal fibre in the pulp and paper industry.

- global papermaking fibre consumption
- global nonwood fibre resources
- specialty fibres for specialty papermaking
- HurterConsult sisal pulp market surveys
- potential sisal pulp applications
- hurdles to overcome
- the next steps

GLOBAL PAPERMAKING FIBRE CONSUMPTION

In 1997, Jaakko Poyry (1) predicted that total global consumption of papermaking fibre would increase from about 300 million tonnes for 1998 to about 425 million tonnes by the year 2010, an increase of 125 million tonnes. Although usage of all types of fibre will grow, they projected that most of this new fibre requirement, about 70 million tonnes, would come from recovered paper. And, the other 55 million tones would come from increased use of fast-growing hardwoods as well as a moderate increase in the use of nonwood plant fibres.

Table 1. Global papermaking fibre consumption (1)
(million metric tonnes)

	Year	Consumption
Actual	1970	135
	1980	180
	1990	250
Projected	1998	300
	2000	330
	2010	425

Increased use of these fibre resources begs several questions.

Is it realistic to rely on recovered paper for 70 million tonnes of fibre over the next two decades?

Recovery rates for wastepaper are already high in most developed countries, the largest per capita paper consumers. For example, U.S. wastepaper recovery rates for corrugated and newsprint are already about 74% and 63%, respectively. The only remaining area where a significant increase in recovery rates may be achieved appears to be printing and writing papers that currently are recovered at a rate of only about 25%. While an increase in recovery rates for these grades may be possible through more effective office waste collection, a large amount of this paper is consumed in the home and discarded in regular trash.

Is this bad for sisal pulp market opportunities?

In my opinion, the answer is no. Even if recovered paper use can be increased by 70 million tonnes, this should be viewed as an opportunity for sisal pulp. It is well established that every time a fibre is recycled it is weaker. Sisal pulp with its high strength properties can be used as a reinforcing additive in papers with a high recovered fibre content.

Furthermore, most fast-growing wood species and the bulk of nonwood plant fibres require some reinforcing fibre to make high quality paper products. Again, increased use of these fibre resources presents opportunities for sisal pulps.

GLOBAL NONWOOD FIBRE RESOURCES

I am including a brief discussion of nonwood plant fibres in general as I believe that their use in the pulp and paper industry will increase substantially over the next few decades and that the use of these fibres also has implications for potential market opportunities for sisal pulps.

Agricultural Residues

Globally, there is an abundance of agricultural residues suitable for pulp and paper production.

Per table 2, Atchison (2) estimated that the global supply of agricultural residues that could be used for papermaking is in the order of 2.448 billion bone-dry metric tons (bdmt).

The key issue is that 99%, or 2.425 billion tonnes, of the agricultural residues are short fibre raw materials with characteristics similar to hardwoods.

So, as the use of agricultural residues increases, potential market opportunities for sisal pulp will also increase because short fibre nonwoods require reinforcing fibre to produce good quality paper.

Fibre Crops

Fibre crops on the other hand present potential competition to sisal pulp because these crops are purposely grown, in part, to produce high quality feedstock for specialty pulp and papermaking.

Per table 3, Atchison (2) estimates that stem fibres account for some 13.7 million bdmt globally of which 3.0 million bdmt is the bast fibre component. Another 580,000 bdmt comes from leaf fibres.

Most of the current fibre crops such as abaca (Manila hemp), jute, sisal and industrial hemp were developed for "traditional" industries such as the rope, twine and carpet backing industries and to a lesser extent for the specialty pulp and paper market.

Table 2. Estimated global availability of agricultural residues [(2)]

Raw Material	bdmt/year
Cereal straws	1250000000
Corn stalks	750000000
Sorghum stalks	252000000
Sugarcane bagasse	102000000
Cotton stalks	68000000
Grass seed straw	3000000
Subtotal short fibre resources	**2425000000**
Flax (oilseed)	2000000
Cotton staple	18300000
Cotton linters	2700000
TOTAL RESIDUES	**2448200000**

Table 3. Estimated global fibre crops [(2)]

Raw Material	bdmt/year
Stem Fibres (jute, kenaf, hemp etc.)	
whole stalk	13700000
bast fibre	3000000
Leaf Fibres	
sisal, henequen, maguey	500000
abaca (Manila hemp)	80000

Summary

Unlike recovered paper that presents potential opportunities for sisal pulp used as a reinforcing fibre, nonwood fibres present both potential opportunities and potential threats to the sisal pulp industry.

The keys to success in developing sisal fibre within the pulp and paper industry will be to recognize both the potential threats and opportunities, and to position sisal accordingly.

SPECIALTY FIBRES FOR SPECIALTY PAPERS

Although the market for specialty pulp and papermaking is very small, since sisal traditionally has been considered a specialty fibre, it is important to understand the nature of this market, current market trends and potential implications for the sisal industry.

Other fibres that are included in the specialty fibre group include:

- abaca
- hemp
- textile flax tow
- oilseed flax straw

Table 4 provides estimates for the use of these fibres in specialty pulp production. It should be noted that Chinese production is excluded from this table as reliable data is extremely difficult to locate.

Key information to be derived from this table is:

- total specialty fibre raw material usage in specialty pulp production amounts to only about 156,000 - 195,000 metric tons per year
- only about 16,000 - 20,000 tonnes per year of sisal fibre are used in specialty pulp production
- the high cost of specialty fibre raw materials is one of the major reasons for the high costs of specialty pulps

Other reasons for the high cost of specialty pulps are the very fragmented nature of the markets thus requiring additional marketing and sales expenses and the high overhead costs associated with producing these pulps in very small pulp mills.

Table 4. Specialty Fibres for Specialty Papermaking

	Units	Abaca	Flax Bast		Hemp Bast	Sisal
			textile tow	oilseed straw		
Primary sources		Phillippines, Ecuador	EU, Egypt	Canada, US	EU	East Africa, Brazil
Specialty pulp uses		• tea bags • porous plug wrap • filtration papers • laminate substrates • abrasion resistant • high value tape base • meat casing • currency	• cigarette burning tube • currency • ultra lightweight printing (bible) • lightweight printing	• cigarette burning tube • lightweight printing	• cigarette burning tube • currency • ultra lightweight printing (bible) • lightweight printing	• tea bags • condenser paper • porous plug wrap • filtration papers • laminate substrates • abrasion resistant • high value tape base • meat casing
Raw fibre used						
total	tonnes/year	50,000 - 55,000	45,000 - 55,000	30,000 - 40,000	20,000 - 25,000	16,000 - 20,000
for in-house pulp	tonnes/year	22,000 - 25,000	30,000 - 35,000	30,000 - 40,000	15,000 - 18,000	14,000 - 15,000
for market pulp	tonnes/year	28,000 - 30,000	15,000 - 20,000	0	5,000 - 7,000	2,000 - 5,000
Raw fibre cost	US$/tonne	US$ 770 - 1,300	US$ 500 - 700	US$ 325	US$ 550 - 650	US$ 700 - 800 (EA)
Raw fibre cost	US$/admt pulp	US$ 1,185 - 2,000	US$ 1,040 - 1,460		US$ 1,040 - 1,230	US$ 1,100 - 1,250
Market pulp cost	US$/admt	US$ 2,800 - 3,100	US$ 1,900 - 2,000	n/a	US$ 1,900 - 2,000	US$ 2,000 - 2,100

NOTES: 1. This table excludes China.
2. Sources: Internal information from Danforth International Trade Associates, Inc. and HurterConsult Incorporated (3)

Furthermore, the use of specialty pulps has been declining over the past 25 years for several reasons:

- technological advancements in papermaking have allowed specialty paper producers to replace all or part of the specialty pulps with woodpulps in certain paper grades
- technological advancements in other areas have eliminated historical markets for specialty pulps - for example, developments in the electrical industry have almost eliminated the need for condenser paper
- cost reductions in the end-user sector have forced changes which have reduced demand for specialty pulps - for example, after the takeover of Reynolds Tobacco, the new owners switched from a flax-based burning tube to a wood-based burning tube which removed a large demand for flax bast fibre from the market.

In summary, although the specialty pulp market historically has offered good profit margins in a small market, the longer term projections indicate that this market may continue to shrink and that competition within this market will become more intense over time.

I believe that any new entrant that is focussed on serving only the specialty pulp market will have a difficult and costly time establishing itself.

HurterConsult MARKET SURVEYS

In the last 12 years, HurterConsult has carried out two preliminary market surveys regarding the potential use of sisal pulp in the pulp and paper industry:

- 1989 survey focussed on sisal pulp for the specialty pulp market (Dominican Republic)
- 1992/93 survey expanded to include the market potential for sisal pulp as reinforcing fibre in commodity papers (Tanzania Sisal Authority)

a) 1989 Market Survey (4)

This market survey was restricted to preselected specialty paper producers and targeted to the most likely users of specialty pulps such as sisal, cotton linters, flax and hemp pulps. The focus area included Western Europe, Canada, the United States and Japan.

The survey was conducted in the following manner:

- for Canada and the US, by telephone interviews with purchasing departments of various mills
- for European locations, by mail - 218 mills contacted with 65 responding (30% response rate)
- for Japan, based on a 1988 survey for specialty pulp usage

For the European locations, two questionnaires were mailed out. The first questionnaire, which also included technical information regarding sisal pulp, asked what types of pulp were currently being used at the mill, whether the mill had ever used sisal pulp, whether the mill would consider using sisal pulp and how much they could use on an annual basis. The second questionnaire was sent to 30 respondents that had indicated that they could use sisal pulp. This questionnaire addressed issues such as desired pulp brightness, forms of delivery and the price that mills would be willing to pay for sisal pulp.

Table 5 presents the results of the 1989 market survey.

Table 5. 1989 sisal pulp market survey for specialty papermaking

Estimated Market Potential		
Canada & US		15,300 - 20,500
Europe	Austria	1000
	Belgium	2000
	Finland	6800
	France	7400
	West Germany	26050
	Greece	4000
	Italy	3 500
	Norway	2 500
	Portugal	50
	Spain	100
	Sweden	5 000
	Switzerland	300
	United Kingdom	6 200
	Yugoslavia	4 000
	Subtotal	68 900
Japan		20,000 - 25,000
Total		**104,200 - 114,400**
Pulp Brightness		
unbleached	small requirement	
Canada & US	86 - 92 %ISO	preferred
Europe	80 - 85 %ISO	50%
	86 - 92 %ISO	50%
Japan	86 - 92 %ISO	preferred
Pulp Pricing		
range	softwood kraft prices up to US$ 2,850/bdmt	
Europe	most respondents indicated no more than twice the price of softwood kraft pulp or US$ 1,660 - 1,680/admt in 1989	

Also, the 1989 market survey provided the following key findings:

- many of the respondents already knew of the potential benefits of using sisal pulp and recognized that certain technical characteristics of sisal pulp could provide value to their paper products
- the potential market was sufficiently large to justify a modest market pulp mill project

- the European response to pricing indicated that the survey had included not only specialty papermakers but also commodity papermakers

- to ensure sufficiently large markets for sisal pulps, the characteristics and price of sisal pulp would be directly related to the characteristics and price of softwood kraft pulps

This project was later abandoned when it was discovered that the Dominican "sisal" was actually another *Agave* species which did not produce acceptable quality papermaking fibre. Nevertheless, the market data provided additional insight to the potential for sisal fibre in the pulp and paper industry.

b) 1992/93 Market Survey (5)

For the 1992/93 Tanzania Sisal Authority study, the market survey was expanded to include both preselected specialty paper producers and commodity paper producers to investigate the market potential for sisal pulp as reinforcing fibre in commodity papers.

As the potential market was global, this market survey was conducted entirely by mail. Using technical data developed during the earlier studies, a specific questionnaire and technical package were developed and mailed to 750 mills which could use sisal pulp either as specialty pulp (140 possible locations) or as a reinforcing fibre in commodity grades (610 possible locations). Response rate to the questionnaire was 27%.

A second questionnaire was sent to 120 respondents that had indicated that they could use sisal pulp. This questionnaire addressed issues such as desired pulp brightness, forms of delivery and the price that the mills would be willing to pay for sisal pulp.

In addition, 28 of the respondents requested samples of the pulp for testing. Bleached sisal pulp was produced and distributed to these respondents for testing.

The results of the 1992/93 sisal pulp market survey are provided in table 6 by end use, table 7 by pulp brightness and table 8 by country. Table 9 presents the estimated selling prices by end use and brightness.

Generally, the results of the 1992/93 market survey provided the following key findings:

- the specialty pulp users already knew of the potential benefits of using sisal pulp and recognized that certain technical characteristics of sisal pulp could provide value to their paper products

- specialty pulp users would be willing to pay high prices for both bleached and unbleached sisal pulps as they had been accustomed to the high pricing of currently available specialty pulps

- the market potential for sisal pulp as a reinforcing fibre in commodity papers is significantly larger than the specialty pulp users portion of the market

- the potential market for sisal pulps as a reinforcing fibre would pay lower prices, prices which would be relative to softwood kraft pulp and the properties of the two pulps

Table 6. Estimated sisal pulp market potential by end use - 1992/93 market survey

	Minimum admt/y	Maximum admt/y
specialty pulp users	15,712	24,662
specialty pulp & reinforcing fibre users	92,550	102,650
reinforcing fibre users	177,990	235,510
unknown	100	100
Total	**286,352**	**362,922**

Table 7. Estimated sisal pulp market potential by pulp brightness - 1992/93 market survey

	Brightness	admt/year
Unbleached Pulp		53,000 - 55,000
Bleached Pulp	80-85% ISO	81,000 - 105,000
	85-90% ISO	82,000 - 108,000
	90-92% ISO	70,000 - 95,000
Total		**286,000 - 363,000**

Table 8. Estimated sisal pulp market potential by country - 1992/93 market survey

	Minimum admt/y	Maximum admt/y
Austria	5,000	7,000
Australia	4,000	4,000
Canada	38,700	48,700
Denmark	2,000	3,000
Finland	15,400	25,400
France	2,900	3,100
Germany	16,600	30,600
Greece	1,500	2,000
India	24,200	24,750
Indonesia	1,000	2,000
Italy	1,050	1,600
Japan	5,030	6,050
Netherlands	10,400	20,400
New Zealand	60	60
Norway	6,000	7,000
Portugal	100	200
South Africa	20,000	20,000
Spain	600	700
Sweden	5,000	10,000
Switzerland	8,500	8,500
Taiwan	22,500	22,500
Thailand	16,000	16,000
United Kingdom	28,051	31,101
United States	51,761	68,261
Total	**286,352**	**362,922**

Table 9. Estimated sisal pulp selling prices by end use and pulp brightness - 1992/93 market survey

		Range (US$/admt)	Majority (US$/admt)
Specialty uses			
	unbleached	520 - 1,750	1,000 - 1,100
	bleached	600 - 3,000	1,200 - 1,500
Reinforcing fibre			
	unbleached	500 - 800	n/a
	bleached	500 - 1,600	1,000 - 1,300
Note: Delivered to purchasers' port basis			

Specifically, International Paper who tested the bleached sisal pulp at their corporate research centre wrote in a letter to HurterConsult (6) that:

- sisal pulp has a tear strength twice that of softwood pulp and three times that of hardwood pulp
- minor refining is recommended to develop tensile strength of sisal pulp without hurting tear strength
- sisal pulp could be used to replace softwood or other expensive high strength pulps
- economic competitiveness of sisal pulp will depend on its characteristics with respect to softwood kraft

International Paper concluded their letter stating that if sisal pulp becomes available on the market at a price of US$ 1,100 - 1,200 per admt, they would be willing to discuss further evaluations at a mill trial scale.

Further, Danforth International (7) who also tested the sisal pulp noted that the test sample:

- was 10% stronger than commercially available sisal pulp
- had lower porosity than commercially available sisal pulp

While the strength properties favour the test sample, the lower porosity is detrimental because currently one of the major uses of sisal pulp in specialty papers is porous plug wrap for which high porosity is critical. Since the test sample was produced as part of a study, it is possible that further process development could improve porosity.

POSSIBLE APPLICATIONS OF SISAL PULP IN COMMODITY PAPERS

Virtually any commodity paper that uses softwood kraft as a reinforcing fibre to provide strength properties to the paper could use sisal pulp instead of, or as a supplement to, softwood kraft.

As early as 1971, an unpublished study (8) showed that sisal pulp could be used in papers with high mechanical wood content. In a commercial trial, newsprint that was being produced with 65% stone groundwood and 35% softwood kraft was replaced with 81% stone groundwood, 10% softwood kraft and 9% sisal pulp.

Also, Fairbanks and Detrick (9) report that *Hesperaloe funifera*, another member of the Agavaceae family, provides an excellent reinforcing fibre for mechanical paper grades. Although this is another fibre resource that is in the early stages of development, the similarities with sisal indicate that sisal also would be capable of the same function in mechanical paper grades.

The potential list of commodity papers which could use sisal as a reinforcing fibre in substitution with softwood kraft pulps is endless and generally can be categorized as:

- high recycle fibre content paper
- uncoated papers which are produced using various mixes of hardwood and softwood pulps
- higher-valued mechanical paper grades such as supercalendered grade A (SCA) and lightweight coated (LWC) papers both of which require a high content of reinforcement pulp (typically softwood kraft) due to high contents of non-fibre fillings or coating materials.
- coated "free sheet" paper which contains about 1/3 hardwood pulp, 1/3 softwood pulp and 1/3 coating material.
- high nonwood fibre content papers where the bulk of the nonwood fibres comes from agricultural residues such as cereal straws

Another possible application for sisal pulp as a reinforcement fibre would be to allow basis weight reductions in commodity papers. Although paper is sold by the tonne, the basis weight of a tonne determines the printing area available. If the basis weight can be reduced while maintaining the other properties of the paper, this would provide more printing surface and could be an incentive for using sisal pulp.

So the question is "Why has sisal pulp not made any inroads in the commodity paper market?"

The simple answers are:

a) the high costs of currently available sisal pulp

b) the availability of reliable sources of supply of sisal pulp with consistent pulp quality

HURDLES TO OVERCOME

Increasing the use of sisal in the pulp and paper industry, especially the commodity paper industry, faces several hurdles that must be addressed and overcome.

a) **Cost**

As discussed, the commodity paper market will view sisal pulp as a replacement for softwood kraft pulp based on the prices and characteristics of the two pulps.

The current cost structure for producing sisal pulps is too expensive if sisal pulps are to be used in commodity papers. As seen in table 4, a large portion of the cost of sisal pulp production is the current cost of raw fibre. Raw fibre cost must be reduced if sisal pulp is to have any success in the commodity paper markets.

b) **Reliability of Supply**

The only previous "large" scale sisal market pulp mill was Cellulose da Bahia, Brazil, built in the early 1980's. This 250 admt/day sisal market pulp mill created a huge amount of interest in sisal pulp, primarily with specialty papermakers but also in some commodity paper grades. Several companies conducted extensive and expensive testing on the pulp and approved its use only to have this source of supply cut off when the mill went into receivership.

This inauspicious beginning for the large scale use of sisal in the paper industry makes it more difficult to establish sisal in the market.

Given the Bahia experience, pulp purchasers in both the specialty and commodity sectors will be reluctant to commit to a new source of sisal pulp even if the cost structure is reduced.

Certainly, having a well designed and managed project will help to relieve concerns over a single new source of supply.

The optimum situation would be if there were at least two new sources of sisal pulp that came into production in the same time frame.

c) **Consistent Quality**

Another of Bahia's problems during its short history was inconsistent quality. Changes in pulp quality can cause problems in paper making operations. Ensuring consistent quality will be a necessary factor for any new mill.

THE NEXT STEPS

In my opinion, there are three critical steps that need to be completed before considering the implementation of a sisal pulp mill project.

1. **New enhanced sisal production system**

A new enhanced sisal production system must be developed and established to provide a continuous and reliable supply of competitively priced sisal fibre suitable for pulp production.

Work in this area began in 1992 when an enhanced production system was designed by Canada Overseas Agro-Industrial Development Inc.(COAID) as part of *HurterConsult*'s 1992/93 feasibility study of the Tanzania Integrated Sisal and Sisal Pulp Mill Project (5) for the Tanzania Sisal Authority.

Mkonge Resource Development Corporation (MRDC) began confirmation of the technical and commercial parameters of this system in 1998 with the active collaboration of Katani Ltd. (the privatized TSA).

Final results of the trials and demonstration of various components of enhanced production system will not be available until the end of 2002. However, Dr. Walid Khayrallah, MRDC President, estimates that, based on preliminary data collected on the rate of establishment and growth of the enhanced plantations, yields in excess of 25 ADMT of fibre per hectare are expected. And, using partial data on the costs of producing sisal over a period of 42 months, Dr. Khayrallah estimates that the cost of in-situ sisal fibre to be less than $80 per dry tonne.

Although the field trials are not complete, data collected to date indicates positive results for lowering the costs of sisal fibre raw material, and this opens real possibilities for reducing the cost of sisal market pulp as required by the commodity market sector.

2. **Detailed Market Study**

Although we have conducted two market studies for sisal pulp, there were limitations on what could be accomplished within the budgetary constraints of the two studies.

I believe that a more detailed market study including mill scale papermaking trials should be carried out.

This would involve the following:

a) identification of a suitable marketing company to take the lead - this company should have a good understanding of sisal pulp, its properties and its potential applications in both specialty and commodity papermaking

b) establishment of interest with potential purchasers in both sectors to test the pulp and to conduct mill scale trials

c) production of sufficient quantities of sisal pulp for mill scale trials using fibre from the new production system - this pulp would have to be produced at an existing mill which has previously processed sisal

d) conduct bench and mill scale trials

This exercise can be expensive as the project sponsors likely would have to underwrite most of the costs; however, it will be a critical step in establishing the marketability of the pulp.

3. **New fibre extraction system**

Traditional fibre extraction methods are too expensive for the production of reinforcing fibre. In our 1992/93 study (5), we proposed a new fibre extraction system and we are generally aware that other systems have been suggested since that time.

Several new approaches to fibre extraction should be thoroughly tested with the view to select the most appropriate system.

This work can be done during the same time frame as the market study and completion of the enhanced sisal production system trials.

In addition to the above, a fourth step should be considered: **investigation of other fibres with exceptional properties that could be grown in the same area and processed in the same mill**.

While there appears to be good opportunities for sisal pulp as a reinforcing fibre in commodity papers if the price of the pulp can be reduced to acceptable levels, having a multi-product mill opens additional market opportunities.

I am suggesting that other plants that grow in semiarid climates such as *Hesperaloe funifera* could provide these additional opportunities.

CONCLUSIONS

Demand for papermaking fibre is projected to increase by 125 million tons per annum by 2010. This demand will be met by about 70 million tonnes of recovered wastepaper with the balance being provided by fast-growing wood plantations and nonwood plant fibres. As these fibre resources are weaker fibres, this provides new opportunities for sisal pulp applications.

Traditional markets for sisal fibre in specialty pulp and paper production are limited and do not leave much room for growth.

New opportunities for the use of sisal fibre as a reinforcing fibre in commodity papers potentially offers large markets.

In order to develop markets for sisal as a reinforcing fibre in commodity papers, the cost structure of producing sisal pulp needs to be reduced with a primary focus on the cost of raw fibre.

A detailed market study including mill scale trials needs to be carried out under the direction of marketing experts who have experience with sisal pulp.

New fibre extraction systems need to be tested.

Alternative fibres which can be grown in the same area as sisal and which can be processed in the same pulp mill should be investigated to provide the pulp mill with product flexibility to meet various market demands.

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